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Original Article

Monitoring noninvasive ventilation in neuromuscular patients: feasibility of unattended home polysomnography and reliability of sleep diaries

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ABSTRACT

Background: In-hospital polysomnography (PSG) often is performed to monitor neuromuscular patients under noninvasive ventilation (NIV), but success of home PSG has not been established for that purpose. Reliability of sleep diaries in neuromuscular patients is unknown. The aims of our study were to evaluate feasibility, quality, and acceptability of unattended home PSG, as well as the reliability of sleep diaries in neuromuscular patients on long-term NIV.
Methods: Fifty-two neuromuscular patients underwent unattended home or hospital PSG during NIV. Patients were questioned about their sleep during the PSG and their attitudes towards the procedure.
Results: One home and one hospital PSG were scored as failure or low quality due to prolonged signal loss or sleep duration of <3 h. Objective and subjective sleep duration and efficiency often showed large differences. Subjective awakenings reflected objective awakenings lasting for >4 min in 86.5% patients. Preference for home PSG was expressed by 82% subjects.
Conclusions: In neuromuscular patients under NIV unattended home PSG is feasible and preferred, with a low failure rate. The degree of reliability of different parameters of subjective sleep assessment should be considered when used as a complement of nocturnal cardiorespiratory recordings.

1. Introduction

Sleep-disordered breathing (SDB) is observed in patients with neuromuscular disorders at various times after diagnosis [1]. It precedes diurnal respiratory failure, which is an unfavorable prognostic marker. Characteristics and severity of SDB differ among patients, partially depending on the type of the neuromuscular disorder and the time after diagnosis. In Duchenne patients in particular a bimodal presentation of SDB has been described, with obstructive sleep apnea (OSA) in the first decade of life and hypoventilation in the second [2]. Nocturnal noninvasive ventilation (NIV) may abolish SDB and prevent or delay diurnal respiratory failure; in cases in when SDB is already present, NIV can alleviate or revert the condition. In addition, NIV alleviates dyspnea and improves performance in daily activities and health-related quality of life [3]. Nocturnal monitoring in neuromuscular patients is essential for identifying when NIV should be initiated and it should be performed routinely, as clinical features increase the suspicion of SDB [4,5]. Further, it is useful to confirm the appropriateness of ventilator setting, both when NIV is started and after its initiation to periodically control its efficacy and modify the setting if necessary. Recent studies have clearly demonstrated that abnormal sleep respiratory events may occur during NIV, even in stable neuromuscular patients on long-term ventilation. These events, mainly caused by air leaks or incorrect ventilator setting, can affect alveolar ventilation and sleep quality [6,7].

When considering nocturnal monitoring in neuromuscular patients, polysomnography (PSG) with continuous carbon dioxide (CO_2) monitoring is considered the best option, not only for diagnostic purposes but also for periodic controls during NIV application, as it allows the evaluation of respiratory disorders, gas exchange, sleep quality, and sleep architecture [8,9]. However, it has not yet been clearly established where this therapy should be performed, with laboratories, hospitals, and home environment being considered as potential settings. From a technical point of view, the laboratory environment is preferable, as a sleep technician is available to supervise patients; moreover, unattended recordings may be associated with unnoticed sensor failure and more often may need to be repeated [10]. However, being studied

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in a sleep laboratory can be challenging for certain patients with advanced neuromuscular disease and special medical needs who are more easily accommodated in specialized neuromuscular centers within hospitals. These centers provide specialized services, facilitating the mobilization of patients and making their stay more comfortable and safe. In such environments unattended PSG may be easily performed, but the procedure may require one night of hospitalization. Home PSG offers a more comfortable environment than hospitalization and enables sleep quality and NIV effects to be similar to those usually experienced by the patient [11]. However, one drawback of home PSG is that somewhat complex equipment must be brought into patients' homes and patients or their relatives may need to cooperate through manually starting and stopping the recording or calibrating the capnograph [12]. These matters raise questions if home PSG may be technically similar or worse than hospital PSG and if its advantages really overcome the disadvantages. To our knowledge, no previous study has assessed feasibility, accuracy, and acceptability of unattended PSG during NIV conducted in different settings among neuromuscular patients.

In addition to cost reduction, labor intensity, and time, another advantage may be found in the use of a home cardiorespiratory monitoring supplemented with detailed information on subjective sleep parameters [13]. In fact, neuromuscular patients also may report sleep concerns during NIV [14]. However, it is unknown if these subjective concerns reflect the objective sleep measures; if they do, this finding may suggest that objective sleep disturbances are possibly caused by inadequate ventilation, thus representing an inexpensive useful complement to cardiorespiratory monitoring. To address these questions, we performed a semirandomized parallel-group study in a relatively large sample of neuromuscular patients. Our first aim was to evaluate the feasibility, failure rate, acceptability, and possible preference of unattended home PSG compared to hospital PSG. As a secondary aim, we evaluated the reliability of subjective sleep parameters in the same patients.

2. Methods

From April 2011 to December 2011, 52 consecutive neuromuscular patients in a stable condition on long-term ventilation, defined as absence of respiratory exacerbations during the previous 2 months, who had been using NIV for more than 3 months, were assigned to two different groups according to their residential area. Group 1 included 26 patients who lived in Palermo, Italy, who were submitted to home PSG; group 2 included 26 patients who lived outside Palermo, Italy, who were studied using hospital PSG. Before inclusion, patients gave written consent to participate in our study. The protocol was approved by the ethics committee. Patients with severe concomitant diseases, mental retardation, or failing (or unable) to give their consent were excluded.

Standard unattended PSG was performed both at home and in the hospital. During the hospital recording, nurses controlled the patients at least twice per night and reapplied the mask, sensors, or electrodes that were displaced. Patients recorded at home were asked to call the technician to solve possible unexpected problems. Three unipolar electroencephalograms (EEGs) (one frontal, one central, and one occipital), right and left electrooculograms, and an electromyogram of the chin muscle for conventional sleep staging were recorded (SomnoLab 2 AASM, Weinmann, Hamburg, Germany). The same device and methodology were used in both settings and the same technician was engaged in the setup of both recordings. Parallel to the PSG recording, partial pressure transcutaneous CO_2 ($PtcCO_2$) was recorded with a SenTec Digital Monitor (software version SMB SW-V04.03). The V-SignTM Sensor was applied to the earlobe with a dedicated Ear Clip (SenTec AG, Therwil, Switzerland). The $PtcCO_2$ device was calibrated before and at the end of each recording to perform automatic drift correction, when necessary, and to improve interpretation of the $PtcCO_2$ values.

Sleep and arousals were scored according to American Academy of Sleep Medicine 2007 criteria [15]. Total sleep time (TST), sleep efficiency (SE) (defined as TST/total recording time $*$ 100), percentage of each sleep stage, and wake after sleep onset (WASO) were calculated. Arousals lasting >15 s were classified as awakenings. Two awakening indices (Aw/I) were calculated: one for all awakenings events lasting $\geqslant$15 s (total Aw/I) and one for events lasting $\geqslant$4 min (4Aw/I). Abnormal respiratory events were classified according to Gonzalez-Bermejo et al. [9]. Asynchronies were evaluated as previously described [16]. Asynchrony index was calculated as sum of all events per hour of sleep time. The following oxygen saturation (SaO_2) parameters were calculated: mean SaO_2, lowest SaO_2, time spent with SaO_2 <90% (T<90), and oxygen desaturation index (ODI) (number of oxygen desaturations $\geqslant$4%/hour). From the $PtcCO_2$ recordings, mean and peak $PtcCO_2$ were automatically calculated after manual elimination of artifacts.

All patients used the same ventilator (IdeaUltra ResMed) with an optional double-limb configuration incorporating an expiratory spirometer and with an appropriate nasal or oronasal mask. The ventilator was equipped with a built-in software (Easy diag Version 1.1.1, SAIME-RESMED, Savigny le Temple, France) for the recording and the measurement of several ventilation parameters, including mean nocturnal minute ventilation and leaks that were automatically calculated as percent differences between inspiratory and expiratory tidal volumes (Vti-Vte/Vti$*$100).

In the morning following the recording, night arterial blood gas values were routinely measured. Then patients were asked to answer a five-item questionnaire about their sleep during the previous night, including time they spent in bed with lights off (time in bed), time taken to fall asleep (sleep-onset latency [SOL]), amount of time spent awake during the night (WASO), total sleep duration (TST), and the number of perceived awakenings. Subjective SE was calculated as subjective TST/time in bed$*$100.

Patients also were asked how they would rate the quality of their sleep the previous night on a scale between 0 (very bad) and 10 (very good). Finally, they were asked how they rated acceptability of the procedure they had undergone (home or hospital PSG) using a visual analog scale from 0 to10 (0 = very bad and 10 = very good), as well as where they would have preferred to perform PSG if they could choose.

2.1. Data quality evaluation

Data were initially reviewed for technical quality and for evidence of abnormalities in breathing, heart rate, and SaO_2 that could require timely participant notification according to criteria for medical alerts (SaO_2 <88% for more than 5 min, $PtcCO_2$ >50 mmHg, heart rate <30 or >150 for more than 2 min). During preliminary review, each study was given an aggregate quality grade based on the overall interpretability and duration of artifact-free signals. Following preliminary review and automatic analysis by the device software, each study was assigned to a trained specialist for manual scoring of sleep and breathing. The quality of the recording was graded according to the criteria by Redline et al. [17], but definitions of fair or good studies were slightly modified to better adapt to requirements for interpretation of studies during NIV application (Table 1). Failure rate of recordings was evaluated as the sum of percentages of poor and unsatisfactory recordings and recordings with a TST of <3 h [18].

2.2. Statistical methods

Because our study was a pilot study, sample size considerations were not based on a predefined clinically significant difference

Table 1
Designations for overall study quality grade.

Unsatisfactory: no usable data (e.g., artifact, software dysfunction)
Poor: respiratory channels (airflow, pressure, and both bands) oximetry, or EEG channels contain less than 4 h of data
Fair: respiratory channels (airflow, pressure, and either band), oximetry, and one EEG signal working for ⩾4 h and <5 h
Good: respiratory channels (airflow, pressure, and either band), oximetry, and one EEG signal working for ⩾5 h
Very good: respiratory channels (airflow, pressure, and both bands), oximetry, and one EEG signal working for ⩾5 h
Excellent: at least on EEG channel, one EOG channel, chin EMG, oximetry, and respiratory channels (airflow and both bands) working for ⩾5 h
Outstanding: all channels working for ⩾6 h

Abbreviations: h, hours; EEG, electroencephalogram; EOG, electrooculogram; EMG, electromyogram.

between hospital and home PSG. Rather the smallest number of subjects (25 per group) that would allow the application of statistical methods was recruited. Patients were semirandomized according to their residence. To assess if the study variables had a normal distribution, the Kolmogorov–Smirnov test was used. Normally distributed data were expressed as mean ± standard deviation and not normally distributed data were expressed as median and interquartile range (IQR).

Comparisons between the groups undergoing hospital and home PSG were performed for participants' characteristics and basic variables. Categorical variables were compared using the χ^2 test, while continuous variables were compared with unpaired *t* tests or Mann–Whitney rank sum tests, as appropriate. For subjective and objective measures of sleep, comparisons were performed with two-tailed paired-sample *t* tests or Wilcoxon signed rank tests. Correlation analyses were performed with Pearson product moment correlation coefficients or Spearman rank tests, as appropriate. A *P* value <.05 was considered statistically significant. Bland–Altman plot concordance methodology also was used to evaluate agreement between subjective and objective measures of sleep and to assess the threshold for differences. Statistical analysis was performed using MedCalc for Windows (Version 11.1.1.0, MedCalc Software, Maria Kerke, Belgium).

3. Results

All 52 patients completed the study. Anthropometric characteristics, baseline respiratory data, neuromuscular impairment according to the Barthel index, and the mode and setting of NIV are summarized in Table 2.

Quality grades of PSG are shown in Table 3. There were no significant differences in quality grade between hospital and home recordings. Temporary loss of EEG or abdominal movement signals were the most common technical problems in both settings. Only one PSG performed in hospital was rated as poor, as it showed airflow signal artifacts for >4 h due to water condensation in the pneumotachograph tube. Quality of all other recordings ranged between fair and outstanding, with most examinations classified in the highest quality classes. However, one patient slept for <3 h at home. That patient's recording accounted for a failure rate of 4.0% both at home and in the hospital. The technician did not receive telephone calls after setting up home PSG. Nurses did not report any need to reposition sensors. Supplementary Tables 1 and 2 reveal that there were no differences in objective sleep and respiratory characteristics between settings. Most patients presented asynchronies, following which they entered an NIV optimization program that could require adjustments in inspiratory and expiratory pressures and measures to minimize air leaks (data not shown).

All patients provided subjective estimates of sleep characteristics and duration, except for WASO which most of them could not quantify, and thus this measure was excluded from the analysis. Subjective and objective measures of SOL, though not significantly different ($P = .67$), were not correlated. By contrast, subjective and objective TST (358 ± 99 vs 345 ± 66 min; $P = .32$) and SE (69 ± 18 vs 72 ± 15%; $P = .25$) did not show significant differences and were significantly correlated ($r = 0.49$ [$P = .0002$] and $r = 0.44$ [$P = .001$], respectively). Subjective Aw/I significantly differed from total Aw/I (median, 0.5 [IQR 0.28–1.00] vs 4.5 [IQR 3.5–6.84]; $P < .0001$), whereas it did not differ from 4Aw/I (median 4Aw/I, 0.70 [IQR 0.30–1.40]; $P = .78$) (Fig. 1) to which it was it strongly correlated ($\rho = 0.72$; $P < .0001$).

Bland–Altman analysis showed that the mean differences between subjective and objective values of TST, SE, and Aw/I were small. A priori we defined as satisfactory limits of agreement differences in TST of <30 min, differences in SE of <10%, and differences between subjective Aw/I and objective 4Aw/I of <1. The 95% limits of agreement were somewhat broad for TST and SE, indicating some disagreement; however, agreement was acceptable for Aw/I (Fig. 2).

Subjective sleep quality was not significantly different between home and hospital PSG (5.44 ± 3.02 and 6.68 ± 2.56, respectively; $P = .12$). There was a significant difference in acceptability (home 8.28 ± 1.99 vs hospital 6.84 ± 2.42; $P = .026$) and preference (home 82% vs hospital 18%; $P < .0001$).

4. Discussion

The importance of our study is related to the increasing need to perform PSG during NIV for neuromuscular patients on a routine basis, while improving patients' comfort when possible without prolonging hospitalization or affecting laboratory or hospital workload. In this context, we hypothesized that unattended home PSG is feasible for most neuromuscular patients and that failure rates of unattended PSG are comparable for home and hospital assessments. Our results showed that sleep recordings were similar in the number of unsuitable examinations and the quality of recordings. However, acceptability and preference among neuromuscular patients were higher at home. Thus home PSG during NIV may be considered a valid alternative to hospital PSG, while it is more acceptable for neuromuscular patients. Subjective evaluation of sleep showed a different reliability, depending on the sleep parameters under consideration.

Sleep respiratory disorders may be recorded using techniques of varying complexity, ranging from fully attended PSG to unattended PSG, cardiorespiratory monitoring, and single-channel recordings. The utility of each level of diagnostic recording has been widely tested in subjects with OSA [19]. In such subjects, studies have shown similar outcomes of PSG in attended or unattended settings (level 1 and 2) [20–22], though other studies found a higher rate of failure for unattended PSG [23,24]. Results obtained in patients with OSA are not comparable to our own as subjects with neuromuscular disease have distinct characteristics, especially severe motor limitation which makes sensor displacement less likely during the night. Reduced spontaneous motility could explain the average high quality of recordings among patients in our study who were not continuously assisted, despite the complexity of the recording which included pressure and flow signals detected

Table 2
Anthropometric characteristics, respiratory and neuromuscular function, and ventilator setting in patients studied in the hospital and at home.

	Hospital	Home	P value
Gender (M/F)	n = 20 M (77%)	n = 18 M (69%)	.75
	n = 6 F (23%)	n = 8 F (31%)	
Age (y)	24.9 ± 9.0	28.8 ± 9.7	.83
BMI (kg/m^2)	21.3 ± 6.1	19.8 ± 6.8	.99
Disease	n = 20 DMD (77%)	n = 14 DMD (54%)	.18
	n = 1 MG (4%)	n = 1 FSHD (4%)	
	n = 1 ALS (4%)	n = 4 MM (15%)	
	n = 1 SMA (4%)	n = 1 ALS (4%)	
	n = 3 DMC (11%)	n = 1 SMA (4%)	
		n = 1 MC (4%)	
		n = 4 CMD (15%)	
Barthel index	30 (IQR 23–30)	30 (IQR 25–40)	.39
FVC (L)	0.94 ± 0.5	0.77 ± 0.5	.33
FEV1 (L)	0.87 ± 0.5	0.68 ± 0.5	.31
MIP (cm$H_2$0)	20.3 ± 15.0	20.8 ± 18.5	.85
MEP (cm$H_2$0)	22.0 ± 11.9	21.2 ± 13.8	.88
pH	7.41 ± 0.04	7.43 ± 0.03	.71
PaO_2 (mmHg)	91.0 ± 11.4	90.2 ± 7.5	.87
PCO_2 (mmHg)	43.0 ± 7.0	40.9 ± 4.8	.98
NIV mode			
PACV	n = 15 (58%)	n = 20 (77%)	.53
PSV	n = 5 (19%)	n = 4 (15%)	
ACV	n = 3 (11%)	n = 1 (4%)	
PSV/VG	n = 2 (8%)	n = 1 (4%)	
Bi-PAP	n = 1 (4%)		
PS (cmH_2O)	15.8 (12–20)	16.0 (12–25)	.81
PEEP (cmH_2O)	1.4 (0–6)	1.04 (0–4)	.46
Backup rate	15.4 (12–18)	16.0 (12–20)	.85
NIV use (h/day)	11.0 ± 4.4	11.2 ± 4.3	.77
NIV use (y)	5.9 ± 3.0	5.2 ± 3.2	.78

Abbreviations: M, male; F, female; y, years; BMI, body mass index; DMD, Duchenne muscular dystrophy; MG, myasthenia gravis; ALS, amyotrophic lateral sclerosis; SMA, spinal muscular atrophy; CMD, congenital muscular dystrophy; FSHD, facioscapulohumeral dystrophy; MM, mitochondrial myopathy; MC, congenital myasthenia; IQR, interquartile range; FVC, forced vital capacity; L, liters; FEV1, forced expiratory volume in 1 s; MIP, maximal static mouth inspiratory pressure; cm$H_2$0, centimeters of water; MEP, maximal static mouth expiratory pressure; PaO_2, arterial oxygen tension; PCO_2, arterial carbon dioxide pressure; NIV, noninvasive ventilation; PACV, pressure-assist control ventilation; PSV, pressure support ventilation; ACV, assist-control volume ventilation; PSV-VG, volume guaranteed pressure support ventilation; BiPAP, bilevel positive airway pressure; PS, inspiratory pressure; PEEP, expiratory pressure; h, hours.
Data are expressed as mean ± standard deviation or median (range).

on ventilator circuit. However, the flow sensor was attached to the ventilator mask, which made it more difficult to lose the signal than with thermistor or nasal cannula used in diagnostic studies [10]. In fact, the abdominal band accounted for the largest proportion of poor signals, most likely because patients did not feel comfortable with a tight band and asked the technician to loosen it.

Regarding the effect of the environment on the technical quality of recordings, a study in subjects with OSA showed that the setting of unattended respiratory monitoring influenced neither the number of valid studies nor the evaluation of the severity of the respiratory disorders [25]. Similarly the rate of success for the hospital and home recordings did not differ in our neuromuscular patients. We hypothesize that some important factors contributed to that result. The most important could be that the patients were initially given some technical information about the recording, including accurate instructions on how to position their interface without damaging the electrodes. In addition, sensors were always fitted at home reducing the likelihood of displacements, unlike in other studies [23,24].

Intuitively sleep quality could be better and duration more adequate at home than in the hospital or laboratory. However, the findings reported to date in patients with OSA are discordant in that respect. Portier et al. [23] reported a longer sleep duration at home than in the laboratory, while Fry et al. [20] observed a shorter sleep duration. Gagnadoux et al. [24] did not find any difference in sleep architecture between home and hospital, while Bruyneel et al. [11] reported a better sleep efficiency at home. In our study, we did not compare the sleep characteristics of the same patients in different environments, as we did not conduct a crossover study. However, the patients studied at home and in hospital showed similar sleep characteristics, with an acceptable sleep quality observed in almost all subjects. In fact, the majority of patients were familiar with the hospital where they usually were admitted for follow-up, and their sleep was not disturbed by the environment.

Table 3
Number of hospital and home polysomnographies with each quality grade.

Studies quality grade	Hospital	Home	P value
Unsatisfactory	0	0	.81
Poor	1* (4%)	0 (0)	
Fair	2° (8%)	1° (4%)	
Good	2°° (8%)	2°° (8%)	
Very good	1^ (4%)	1^ (4%)	
Excellent	10 (38%)	13 (50%)	
Outstanding	10 (38%)	8 (31%)	
TST <3 h	0	1** (4%)	

Abbreviations: TST, total sleep time; h, hours.
* Flow <4 h.
° Poor electroencephalogram (EEG) or electromyogram (EOG) in hospital, poor oximetry trace at home.
°° Displacement of abdominal bands.
^ Poor EEG in hospital and poor EOG at home.
** TST <4 h.

Although a greater comfort may be expected by sleeping at home rather than in the hospital, not all previous studies found a preference for home recordings. In some cases, apprehension about the outcome of an unassisted recording or complexity of organizing home recordings led patients to express a preference for the hospital [24] or laboratory recordings [20,23]. In contrast and similarly to other studies [11,21], we found that our neuromuscular patients willingly accepted tasks related to positioning of the mask, removing sensors, calibrating of PtcCO_2, and transporting the equipment to the hospital the following day. When asked, they declared a clear preference for home PSG.

The second aim of our study was to determine if there was a relationship between subjective and objective sleep measurements. Unlike other patient populations for whom simple tools such as actigraphy could be used to evaluate sleep duration, a combination of cardiorespiratory monitoring and sleep diary may be the only alternative to PSG in neuromuscular patients. Few studies have compared subjective and objective sleep parameters. The high variability of the results reported so far also could depend on the kind of population studied, which often include healthy subjects [26,27], depressed patients [28,29], or insomniacs [30]. No study thus far has evaluated the reliability of subjective sleep reports among neuromuscular subjects.

Our results indicate that neuromuscular patients were inaccurate in reporting SOL. Subjects were somewhat more accurate in reporting of TST and SE; however, the limits of agreement often were exceeded even when the bias was low, indicating a greater interindividual variability and the unreliability of these two subjective sleep parameters. However, almost all subjects slept for >3 h. According to previous suggestions, a 3-h sleep time may be enough to evaluate efficacy of nocturnal mechanical ventilation [18]. Therefore, subjective TST should not be considered as an essential parameter to assess the validity of a cardiorespiratory nocturnal monitoring when performed to evaluate the efficacy of NIV. Unlike TST and SE, subjective Aw/I was a strong marker of sleep fragmentation, as it reproduced the 4Aw/I in more than 80% of patients. The relationship found between the rate of

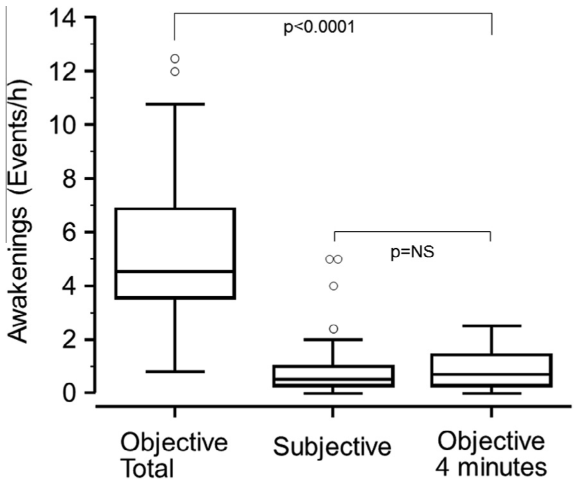

Fig. 1. Box plot distributions for total objective awakening index, objective 4 min awakening index and subjective awakening index. The boxes show the median and 25th and 75th percentiles and the whiskers indicate the 10th and 90th percentiles. Open dots: outliers.

subjective and 4 min awakenings in our study is in agreement with the literature, as healthy young men were reported to be able to accurately estimate their number of awakenings only when they lasted for >4 min [31]. The assessment of subjective awakenings may be a factor that could help to determine if NIV improves or deteriorates sleep quality and if modifications are required to the NIV setting.

A precise analysis of costs was beyond the scope of our study. However, only the cost a technician (approximately 150.00 euros) has to be added to the examination cost when PSG is performed at home, which is substantially less than the cost of a one-night stay in the hospital (350.00 euros in our department). Because home examinations rarely require repeating, the economic advantage of home recordings is evident.

The main limitation of our study was the lack of a crossover design. Furthermore, we did not evaluate internight variability of each test. The choice of a parallel design with a single recording for each subject aimed to limit the burden for the patients to undergo multiple PSG. Another limitation was that validated sleep questionnaires or sleep logs were not used. However, we used our own questionnaire because we were not interested in assessing overall subjective sleep quality. Instead we aimed to compare similar quantitative sleep parameters obtained scoring PSG or based on patient interviews. Finally, the quality of home PSG should have been compared with the gold standard, which is in-laboratory PSG. However, because the majority of neuromuscular patients are evaluated in a specialized hospital setting, we felt that the settings chosen for comparison would be more appropriate for this special population.

5. Conclusion

Our study supports the feasibility and clinical usefulness of unattended PSG for the evaluation of sleep and NIV quality in neuromuscular patients on long-term ventilation. In addition, it indicates that the home environment is appropriate for such recordings in adequately trained subjects, as home recordings are subjectively perceived as more comfortable and have a similar technical quality as a hospital recording, thus saving the cost of one night of hospitalization. Among the subjective sleep parameters Aw/I was reliable reflecting the rate of awakenings ⩾4 min, though subjective SOL, TST, and SE lacked accuracy.

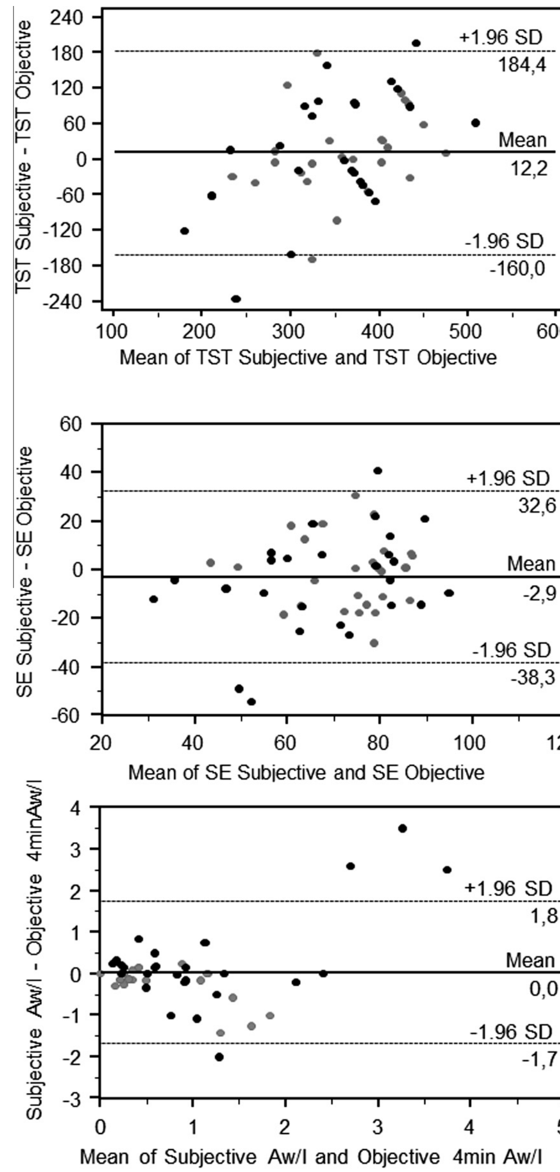

Fig. 2. Bland–Altman plots for objective and subjective sleep variables. Black dots: home polysomnographies. Grey dots: hospital polysomnographies. Upper panel: total sleep time. Middle panel: sleep efficiency. Lower panel: awakening index.

The practical implication of these findings is that a cardiorespiratory recording in association with sleep questionnaires cannot always effectively replace a full PSG. However, almost all subjects slept for >3 h during PSG with NIV, suggesting that a short sleep duration rarely leads to a misinterpretation of the effects of NIV if EEG is not recorded. Criteria for the requirement of a complex monitoring with EEG could include poor patient-ventilator interaction or subjectively disturbed sleep for unclear reasons, but this hypothesis needs to be clearly identified. Further studies should aim to confirm the usefulness of cardiorespiratory recordings in association with subjective reporting of awakenings in the assessment of NIV adequacy or modifications in this setting.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2013.09.029

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.sleep.2013.09.029.

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